Scattering Studies Based On The Method of Ordered Multiple Interactions
(MOMI)

FINAL PROGRESS REPORT

Jakov Toporkov
Gary S. Brown

1 March 1997

U.S. ARMY RESEARCH OFFICE

DAH04-96-1-0374

VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY

APPROVED FOR PUBLIC RELEASE

DISTRIBUTION UNLIMITED

DTIC QUALITY INSPECTED 3

19970902 111

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB NO. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comment regarding this burden estimates or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE 1 March 1997	3. REPORT TYPE AND DATES COVERED Final Progress Report(16 Aug.1996-15 Feb.199

4. TITLE AND SUBTITLE Scattering Studies Based on the Method of Ordered Multiple Interactions (MOMI)	5. FUNDING NUMBERS ① DAAH04-96-1-0374
6. AUTHOR(S) Jakov Toporkov Gary S. Brown	

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES) Electromagnetic Interactions Laboratory Bradley Department of Electrical Engineering Virginia Polytechnic Institute & State University Blacksburg, Virginia 24061-0111	8. PERFORMING ORGANIZATION REPORT NUMBER None

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSORING / MONITORING AGENCY REPORT NUMBER ARO 34695.2-EL

11. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision. unless so designated by other documentation.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.	12 b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report summarizes findings pertaining to the current sampling that is required for the Method of Ordered Multiple Interaction or any Method of Moments solution for scattering from roughened planar surfaces. The results are valid for both a Gaussian roughness spectrum and a power low spectrum having a 2-D asymptotic roll off of k^{-3}.

14. SUBJECT TERMS Random Surfaces Electromagnetic Scattering Integral Equations	15. NUMBER IF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL

REPORT TITLE: Final Summary Report
INVESTIGATION TITLE: Scattering Studies Based on the Method of Ordered Multiple
Interactions (MOMI)
INVESTIGATOR: Gary S. Brown
INSTITUTION: ElectroMagnetic Interactions Laboratory
Bradley Department of Electrical Engineering
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061-0111
GRANT NUMBER: DAAH04-96-1-0374
PROBLEM, MOST IMPORTANT RESULTS, AND SUMMARY:

Conventional wisdom for sampling the current on a perfectly conducting scattering body holds that $0.1\lambda_o$ is an adequate sample spacing. This result applies to bodies that are usually large compared to a wavelength and which have no features that are comparable to or smaller than one electromagnetic wavelength (λ_o). When dealing with scattering from rough surfaces that have *many scales* of roughness, this conventional wisdom is highly suspect. The intent of the research reported below was to study this problem and to attempt to come up with some guidelines for sampling the current on such a rough surface.

In this research we examined the Fourier transform of both the kernel or propagator in the Magnetic Field Integral Equation (MFIE) and the Kirchhoff term and found them both to be essentially band-limited. That is, we found that they both became very small in magnitude outside a band of wavenumbers determined by the electromagnetic wavenumber (k_o) and the upper cut-off wavenumber of the surface roughness spectrum (k_c). The fundamental implication of this result is that the current itself will also be band-limited and this fact was verified by computation using either a standard Method of Moments (MoM) approach or the Method of Ordered Multiple Interactions (MOMI).

Since all the functions in the integral equation are band-limited, the unknown current can be best reconstructed using $\sin(\alpha x)/(\alpha x)$ testing and basis functions sampled at a Nyquist rate of twice the highest wavenumber present in the functions, i.e.,

$$2k_u = 2(k_o + k_c)$$

which leads to a sampling interval Δx given by

$$\Delta x = \frac{\lambda_o}{2(1 + k_c / k_o)}.$$

It should be noted that this sampling procedure is the direct opposite of what is usually used in MoM-type solutions. That is, we use basis and testing functions that have infinite support in the spatial domain while having a finite support in the transform domain whereas in conventional MoM approaches one uses rectangular basis functions in the spatial domain. Based on the above discussion as to the band-limited nature of the functions in the integral equation for rough surfaces having band-limited or cut-off roughness spectra, it is clear why the infinite spatial support interpolating functions should be used.

An additional result that comes from this analysis is the fact that when one uses the above interpolating functions in discretizing the integral equation for the current, the question of how to deal with the propagator is answered with no ambiguity.